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AIR BOUND FILTERS

By James M. Caird

There is very little literature on troubles encountered in the operation of water purification plants. The collection of air within a filter bed is a very serious matter and up to the present time the writer is not aware of any method which will successfully prevent this trouble.

The writer's idea as to the cause of air bound filters is as follows:

1st, The lower the temperature of water, the greater the volume of air it may contain.

2nd, During cold weather, water is usually saturated with air.

3rd, Water in passing through filters increases in temperature, liberating air.

4th, The voids in the gravel are greater than in the sand, therefore the air collects in the gravel.

5th, The weight of the sand in American type filters is not sufficient to hold the air in the gravel, therefore the sand beds become perforated.

6th, The weight and fineness of the sand in English type filters are such that it holds the air in the gravel, hence the filter is unable to pass water.

The action of collected air in the American type filter is entirely different from the action in English filters. In both types of filters the trouble seems to be due to the collection of air in the gravel just below the sand layer. Air bound troubles seem to be most frequent when the temperature of the unfiltered water is below 50°F.

In filters of the American type the air seems to collect below the sand until it forces its way up through the sand, perforating the bed, which of course results in imperfect filtration. In filters of the English type, the air collects in the gravel, but does not seem to be of sufficient quantity to force its way up through the bed; but it overcomes the head of water and prevents any water passing the bed.

It may be of interest to consider the air bound conditions in some places.

In the *Annual Reports of the Board of Water Commissioners*, Harrisburg, Pennsylvania, for the years 1907, 1908, 1909 mention is made of the troubles due to air collecting in the filters. The Harrisburg filters are of the American gravity type. The troubles at Harrisburg always come during the cold weather when the temperature of the water is low and the color and turbidity content of the unfiltered water are at a minimum. At such times the air collects in sufficient quantity in the gravel to force its way up through the sand, perforating the bed, and permitting undesirable water to pass. During such periods extra care is used in operating the plant and frequent inspection is made of the loss of head gauges which show when it is advisable to remove the air from the beds. When there is a loss of head of about 3.5 feet, it is advisable to put the bed out of service and apply the wash water for about two minutes, which removes the entrained air. When the air troubles exist the filters are usually given one of these short washes between the regular washes, the beds are then agitated by air. By using this method of operation it has been possible to get good filtration results.

At Bangor, Maine, where filters of the American gravity type are operating on a water which changes very slightly in composition, it is found that it is necessary to reduce the periods very materially between washings during the winter months. At Bangor, when the temperature of the unfiltered water falls to 48° F. the operator begins to reduce the periods of time between filter washings, disregarding the indicated loss of head. In winter the periods between washings are at least 50 per cent less than in summer when the temperature of the water is about 70° F. This method of operation has been very successful. These conditions are mentioned simply as illustrations and are not alone peculiar to these places.

At Wilmington, Delaware, where filters of the English type are operated at a rate of six or seven million gallons per acre per day, air has been the cause of very serious trouble. In the *Annual Reports of the Water Department*, Wilmington, Delaware, for 1911–1912, 1912–1913, 1913–1914 mention is made of the troubles caused by air bound filters. In the Wilmington case it has been necessary, at times, to "by-pass" settled water because the collected air would completely prevent filtration. If it were not for the fact, that all of the water is treated with liquid chlorine before being delivered to the consumers, the grave danger of "by-passing" would almost amount to murder. As with the filters of the American type, the air troubles at Wilmington come when the temperature of the water is about 45° F. or below. The Wilmington filters are covered and it is found that the temperature of the water increases in passing the filter beds.

For some time past a study of the relation of the dissolved oxygen content of the unfiltered and filtered waters to the air binding of the beds has been made.

Table showing average monthly temperature, dissolved oxygen in per cent saturation before and after filtration and per cent removed, Wilmington, Del.

DATE	TEMPERATURE	PER CENT SATURATION		PER CENT REMOVED
		Before	After	
1913	*Degrees F.*			
October	60.5	90.79	65.43	27.9
November	48.5	95.06	81.54	14.3
December	40.2	97.76	85.94	12.1
1914				
January	34.6	94.18	84.07	11.3
February	35.6	96.97	84.29	13.1
March	37.8	97.39	88.30	9.4
April	52.6	94.19	70.09	25.6
May	66.0	91.49	51.75	43.5
June	74.6	97.08	39.03	59.8
July	76.2	84.70	42.70	49.6
August	77.2	87.20	43.80	49.8
September	70.0	95.20	63.20	33.7
October	62.7	87.80	61.10	30.8
November	46.4	96.80	82.90	14.4
December	37.6	100.00	90.90	9.1
1915				
January	37.4	100.00	90.80	9.2

In March and December, 1914, there were serious troubles, due to air in the beds. It is to be noted that these troubles followed a period of low temperatures of the water before filtration and that the water was about saturated with oxygen. It is also to be noted that the per cent of dissolved oxygen removed at these times is very low.

When the filters are air bound, if a bar be driven through the sand to the gravel layer, and then removed, large volumes of air will escape. Reducing the head of water over the sand surface does not permit the air to escape.

Up to the present time the best method used to overcome this trouble is to back wash the filter bed. In doing this it is necessary to use great care so as not to displace the sand layers. This procedure of course reduces the bacterial efficiency of the filter.